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Project Summary

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Use of a Vegetative Filter Zone to Control Fine-Grained Sediments from Surface Mines

Steve C. Albrecht and Billy J. Barfield

The objective of this study was "to demonstrate the effectiveness of a vegetative filter zone in trapping fine-grained sediments from surface mining operations." The area selected for study was located in Whitley County, Kentucky, directly below an active surface mining operation. The outslope above the filter was the primary drainage area monitored during this study.

This project was initiated for the specific purpose of conducting a field test on vegetation as a viable sediment trapping medium. From the onset, the project was wholly designed for a field evaluation under typical mining conditions. The filter area was constructed directly below an abandoned surface mine bench, on typical soil types found in mined areas of Eastern Kentucky. The outslope located above the filter was the primary area, from which sediment-laden drainage was to be diverted to the inlet monitoring station. Sediment-laden water samples were collected at the inlet flume for comparison with samples collected at the outlet flume to permit evaluation of the sediment removal capability of the vegetative filter.

Results of the monitoring efforts revealed that a dramatic reduction in sediment load was achieved by vegetative filtration for particle sizes larger than clay. Based on the results of this study, it was concluded that vegetative filters are an effective control for reducing the quantity of sediment transported into surface streams and rivers from disturbed mined lands.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The coal regions of the United States are richly endowed with abundant mineral resources. The surface mining of these valuable resources results in a major disturbance of the land. This disturbance interrupts a natural balance between soils and geologic formations established over many years. When highly erodible surface material is broken up, a natural pollutant, sediment, is introduced into rivers and streams. Surface mining operations often serve to accelerate the amount of sediment introduced into the environment. The resulting sedimentation can adversely affect local and surrounding ecosystems.

Various structures such as ponds, rock dams, silt fences, as well as other devices can be used to control sediment on surface mining operations. This report addresses the usefulness of one particular type of sediment control structure, the vegetative filter zone.

The objective of this study was to demonstrate under actual field conditions the technical, economic, and environmental feasibility of using a cultivated vegetative filter zone to assist

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in controlling fine-grained sediments originating from surface mining operations. Project evaluation criteria focused on the sediment trapping efficiency of the filter, the suitability of selected types of vegetation for use within the filter zone, the filter's usefulness in improving water quality, and its cost feasibility.

Description of Results

The filter was constructed in the late spring of 1979. The flow was diverted away from the filter area while vegetation was being established. Flow was diverted into the filter in the late fall of 1979 and monitoring equipment installed. During the months of January and February, the monitoring equipment was removed to prevent freeze damage. During that period, storms were hand-sampled whenever possible. Monitoring equipment was reinstalled in the spring of 1980, and monitoring continued until November, 1980. During the monitoring period, several storms of sufficient magnitude occurred to cause runoff and flow through the filter. One storm, with a duration equal to two hours, had a return period of over 100 years. The data from these storms are summarized below. Details of filter construction, operation, sampling, analyses, and suggestions for design and use of vegetative filters are presented in the full report.

Storm of January 11, 1980 - An unusually warm period in January brought rains and runoff at the filter site. All equipment and records had been removed for the winter but the flow was hand sampled for a thirty minute period for sediment concentration only. The storm did not generate massive amounts of sediment; the peak concentration was only 6,750 mg/l. Outflow concentrations were typically 500 to 600 mg/l, with the exception of one sample that was 1600 mg/l. Ninety-two percent of the sediment was trapped in the filter area, indicating that the filter was performing well.

Storm of April 3, 1980 - On April 3, 1980, a complete data set was taken by hand sampling the inflows and outflows and by measuring flow depths in the H-flumes with point gauges. The sediment concentrations are shown in Figures 1 and 2. The peak inflow and outflow rates were 0.11 and 0.03 cfs (3.11 and .85 l/sec) respectively, indicating a significant attenuation of the flow rate, due primarily to infiltration. The infiltration volume was 54 percent of the inflow volume.

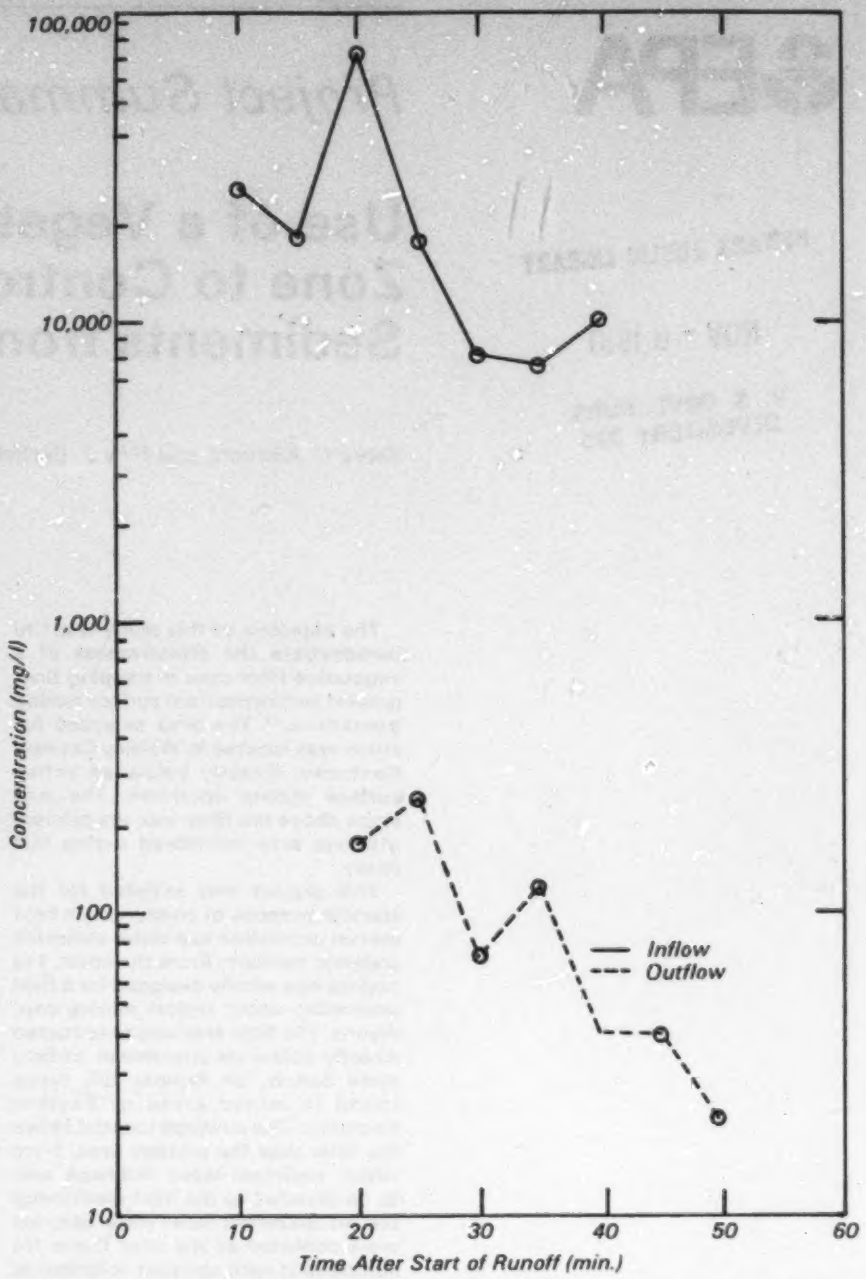

Figure 1. Inflow and outflow sediment concentrations for storm on April 3, 1980.

Storm of May 24, 1980 - The storm of May 24, 1980, was monitored by automatic equipment. The ink in the water stage recorder on the inflow H-flume smeared badly, making it impossible to determine an inflow hydrograph. Since outflow rates were very low, it may be assumed that inflow rates were also low. Peak and average inflow concentrations were 911 and 522 mg/l. The trap efficiency, based on inflow and outflow concentrations was 98.3 percent.

Storm of July 10, 1980 - The runoff from the July 10 storm was sampled by automatic equipment. Peak inflow and

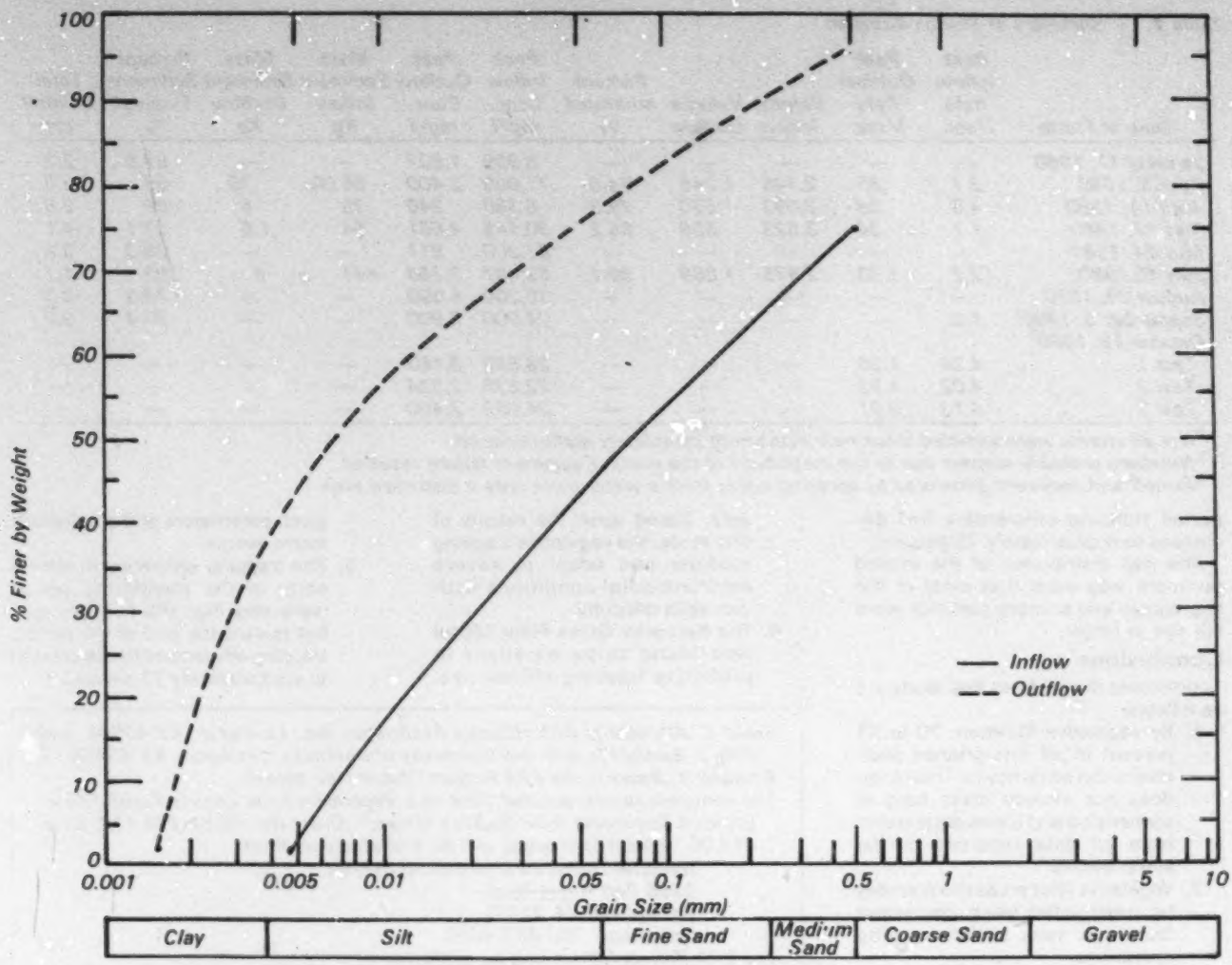

Figure 2. Aggregate size distribution of sediment for storm on April 3, 1980.

outflow rates were 0.070 and 0.047 cfs (1.98 and 1.33 l/sec). Infiltration accounted for 35 percent of the inflow. Peak and average inflow concentrations were 3788 and 1420 mg/l. The trap efficiency, although flows were low, fell to 97.1 percent.

Storm of August 29, 1980 - The storm of August 29 was sampled by automatic equipment. The ink pens for the water stage recorders did not work properly, therefore only the concentrations can be calculated from the data. The trapping efficiency of the vegetation was only 78.3 percent during this test, which was the lowest value for the filter to that date. By this time, however, considerable deposition has occurred throughout the filter. The aggregate size distribution of the eroded sediment was such that 99 percent of the sediment was silt size or larger, indicating the filter continued to provide good trapping.

Storm of September 3, 1980 - The storm of September 3, 1980, was monitored by automatic equipment. According to the rainfall charts, over 9.0 cm of rain fell. This represents an intensity which has a return period of over 100 years. An inspection of the site after the storm indicated that massive amounts of sediment had washed in during the storm, plugging the stilling wells and partially plugging the inlet to the pumping sampler. Sediment had also deposited in the middle of the filter with numerous boulders, four inches (10.2 cm) in diameter, washed as far as 40 feet (12.2m) into the plot.

Approximately 20 percent of the filter was completely inundated where sediment, in large amounts, deposited in the vegetation.

Summary

In summary, the vegetation (fescue) worked well as a filter for most of the year. The storms evaluated are summarized in Table 1. The 100+ year storm which occurred on September 3, 1980, caused significant deposition in the filter. Subsequent tests showed a decrease in trapping efficiency. The trapping efficiency in storms early in the monitoring period were very high, (95-100 percent), but toward the end of the

Table 1. Summary of Storms Sampled

Date of Storm	Peak Inflow Rate l/sec.	Peak Outflow Rate l/sec.	Volume Inflow	Volume Outflow	Percent Infiltrated %	Peak Inflow Conc. mg/l	Peak Outflow Conc. mg/l	Mass Sediment Inflow Kg	Mass Sediment Outflow Kg	Percent Sediment Trapped %	Total Rainfall cm
January 11, 1980	—	—	—	—	—	8,939	1,607	—	—	92.5	2.2
April 3, 1980	2.1	.85	2,745	1,245	54.6	71,000	2,400	85.00	.35	>99	2.6
April 11, 1980	4.8	.36	8,093	1,670	79.3	6,380	240	39	.6	>99	2.8
May 17, 1980	1.1	.34	3,623	538	85.2	30,148	4,651	54	1.6	97.1	4.1
May 24, 1980	—	—	—	—	—	67,200	911	—	—	98.3	3.8
July 10,1980	12.7	1.33	2,575	1,669	35.1	62,487	3,788	441	5	>99	1.2
August 29, 1980	—	—	—	—	--	30,200	5,600	—	—	78.3	2.3
September 3, 1980[2]	1.9	—	—	—	—	24,900	5,900	—	—	70.4	9.0
October 18, 1980[3]											
Test 1	4.24	1.36	—	--	—	28,692	3,180	—	—	—	—
Test 2	4.02	1.93	—	—	—	22,636	2,324	—	—	—	—
Test 3	4.13	2.91	—	—	—	24,030	2,460	—	—	—	—

[1] *Not all storms were sampled since new equipment completely malfunctioned.*
[2] *Numbers probably suspect due to the magnitude of the event. Equipment failure resulted.*
[3] *Runoff and sediment generated by spraying water from a water truck onto a disturbed area.*

period trapping efficiencies had decreased to approximately 75 percent.

The size distribution of the eroded sediment was such that most of the aggregates and primacy particles were silt size or larger.

Conclusions

Conclusions drawn from this study are as follows:

1. By vegetative filtration, 70 to 99 percent of all fine-grained sediments can be removed. This range does not include clays held in suspension and it was determined from all data recorded during storm events.
2. Vegetative filter areas can normally be constructed using equipment found on most surface mining operations.
3. Vegetation used in the filter are subjected to high stress conditions. Response to this stress was excellent despite acid inflow into the area. Based upon the results of this study, the vegetative trapping medium can adapt to severe environmental conditions with very little difficulty.
4. The Kentucky Grass Filter Model was found to be excellent in predicting trapping efficiencies, given parameters of the individual storm events.
5. The trapping efficiency in storms early in the monitoring period were very high (95-100 percent), but toward the end of the period, trapping efficiencies had decreased to approximately 75 percent.

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***Edward R. Bates** is the EPA Project Officer (see below).*
The complete report, entitled "Use of a Vegetative Filter Zone to Control Fine-Grained Sediments from Surface Mines," (Order No. PB 81-226 110, Cost: $14.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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Telephone: 703-487-4650
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